REPORT OF

CARBONADO MINE EXPLOSION

April 12, 1930

at

CARBONADO MINE

PACIFIC COAST COAL COMPANY,

PIERCE COUNTY, WASHINGTON.

by

S. H. Ash and John G. Schoning

U. S. DEPARTMENT OF COMMERCE

BUREAU OF MINES

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By

S. H. Ash[1] and John G. Schoning[2]

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INTRODUCTION

An explosion occurred in the Second Level Douty No. 8 bed workings of the Carbonado Mine of the Pacific Coast Coal Company, Carbonado, Washington, on April 12, 1930, at about 5:30 P. M., whereby 17 men were killed, who[illegible] were all of the men employed in the section of the mine where the disaster occurred, at the time of the explosion.

It is the writers' opinion that the explosion was caused by a windy shot resulting from improper blasting of two or three shots, probably two, at the face of No. 5 temporary chute in the Second Level South of Douty No. 8 seam. The bed "generates" methane, which, if not present immediately before blasting, was probably present after the first shot. In addition, there was an unknown amount of dry fine coal dust present, which is very explosive. Coal dust was not treated in any manner in the affected district.

Mr. Schoning was notified of the disaster at 7:15 P. M., and arrived at the scene of the explosion at 8:35 P. M.

The following is an account of Mr. Schoning's activities and events up until the arrival of Mr. Ash on April 16, 1930.

About 7 P. M. on April 12th Mr. Schoning was notified of the explosion. He immediately left Seattle by way of mine rescue truck, taking with him complete equipment, and arrived at Carbonado at 8:35 P.M. On arriving he got in touch with Mr. W. A. Wilson, Manager of Mines for the Company, and was informed that 17 men had checked in for work on the afternoon shift in the district affected by the explosion. Several bodies had been located and were being brought to the surface, and an apparatus crew of five men, using Gibbs apparatus, was exploring the pitch workings to locate any live men or bodies, and to ascertain if any fires had been started by the explosion. A reserve mine rescue crew of 5 men, similarly equipped, was on hand. It was stated that the mine rescue crews worked about 3 hours using the apparatus.

A man stationed at a telephone at the First Aid station at the bottom of the electric slope kept the office informed as to the progress being made in the recovery work.

About 9 P.M., April 12th, Messrs. Wilson and Schoning went to the mine mouth and arranged for the bodies to be brought to the machine shop for identification. The recovery work was completed and all bodies removed to Buckley by 1 A.M. on April 13th. It was stated that about one hour elapsed between the time of the explosion, and until the first bodies

were recovered by a fresh air crew consisting of 4 men led by Wm. Mataya, fireboss. Recovery was quite rapid as the ventilation was not badly disarranged.

About 9 A.M. April 13th a party consisting of Messrs. W.A.Wilson, Manager of Mines; Paul Gallagher, Mine Foreman; Stanley Smith, Assistant Foreman; B. F. Snook, Fire Boss; William Williams and Martin Hamlin, employee representatives of the Mine Safety Committee; William R. Reese, State Mine Inspector; George T. Wake, Deputy Mine Inspector; and Mr. Schoning, U. S. Bureau of Mines, went underground to ascertain, if possible, the cause of and place where the explosion originated.

After making a thorough exploration and examination of the Second Level Douty No. 8 workings, the party returned to the surface. A conference was held at which Mr. Reese questioned those of the investigating party who might be able to furnish information as to the general mining practice and firing of shots. Each member of the investigating party was asked for his opinion as to the cause and place of origin of the explosion. All of them were of the opinion that the explosion originated in No. 5 chute South.

On April 15th a party consisting of Messrs. James Dixon,Chief Mine Inspector of British Columbia; Thomas Murphy, Superintendent Northwestern Improvement Company; Jos. Lee, Manager, Wilkeson Coal & Coke Company; William Hann, Manager, Washington Union Coal Company; James Pascoe, Superintendent,Bellingham Coal Mines Company; James Bagley, President,

Bucoda Coal Company; David C. Botting, Associated Industries; W. A. Wilson, Manager of Mines, Pacific Coast Coal Company; Paul Gallagher, Mine Foreman, Carbonado Mine; Stanley Smith, Assistant Mine Foreman, Carbonado Mine; William Williams and Martin Hamlin, employee representatives, Safety Committee of the Carbonado Mine; and Mr. Schoning, U. S. Bureau of Mines, made an inspection trip through the area affected by the explosion.

Upon returning to the surface a conference was held, at which each member of the party gave his opinion as to the cause and place where the explosion originated. All concurred in the previous decision that the explosion originated in No. 5 chute Second Level South, Douty No. 8 bed; and that the probable cause was a windy shot which resulted when an excessive amount of permissible explosive was blasted electrically in the holes that were drilled in the face of the chute.

On arriving at Seattle, Washington, on the morning of April 16th, 1930, Mr. Ash got in touch with Mr. N. D. Moore, Vice-President, and Mr. Wm. Wilson, Manager of Mines, of the Pacific Coast Coal Company, and arrangements were made whereby the writers went to Carbonado and proceeded to further investigate the cause and nature of the disaster.

The underground inspection by the writers was made on April 17th in company with Mr. Paul Gallagher, Mine Foreman; Mr. Stanley Smith, Assistant Foreman; and Messrs. Martin Hamlin and William Williams, miners' representatives of the Mine Safety Committee.

The following report is based on conditions observed at the time of this visit, together with Mr. Schoning's previous experiences, and personal conversation with management and operating officials of the Pacific Coast Coal Company.

LOCATION

The Carbonado mine is situated at Carbonado, Pierce County, Washington, on the Fairfax branch of the Northern Pacific Railway, about 60 miles southeast of Seattle. The company officially are:

Mr. E. C. Ward, President, L.C.Smith Bldg., Seattle,Wash.

Mr. N. D. Moore, Vice-President, " " "

Mr. W. A. Wilson, Manager of Mines," " "

Mr. R. W. Smith,Chief Mining Engineer, " " "

Mr. Robert Simpson, Superintendent, Carbonado, Wash.

Mr. Paul Gallagher, Mine Foreman, " "

The original copy of this report should be sent to Mr. N. D. Moore, Vice-President, L. C. Smith Bldg., Seattle, Washington.

The mine is owned and operated by the Pacific Coast Coal Company, L. C. Smith Bldg., Seattle, Wash.

EMPLOYEES AND PRODUCTION

During the year 1929 the average number of employees at the Carbonado mine was as follows:

Underground	-	223	employees;	478,144	man-hours worked
Surface	-	65	"	139,376	" "
Total	-	288	"	617,520	" "

A working day of 8 hours is in effect at this mine and coal is hauled on two shifts, although portions of the underground workings are at times worked three shifts.

All gangways, counters and temporary chutes work three shifts with the exception of No. 4 gangway. The West No. 8 stumps are worked on three shifts.

In the Douty No. 8 Bed workings, the chutes were working two shifts above the counter, but all other places were working three shifts. This is the district where the disaster occurred.

The times of starting and quitting of the shifts are as follows: Morning shift, 7 A.M. to 3:20 P.M.; afternoon shift, 4 P.M. to 12 P.M.; night shift, 12 P. M. to 7 A. M.

The production during 1929 was 192,903 short tons; the average days worked was 289; the average daily production was 672 short tons.

At the time of the disaster the average daily production was 641 short tons. The average total number of employees during March, 1930, was distributed as follows:

	Day Shift (7A.M. - 3:20 P.M.)	Afternoon Shift (4 P.M. - 12 P.M.)	Graveyard Shift (12 P.M. - 7 A.M. following calendar day)	TOTAL
Underground				176
Surface				51
Total				218

On April 12, 1930, the day of the disaster, the employees were distributed as follows:

		(When explosion occurred) Day Shift (7 A.M.-3:20 P.M.)	Afternoon Shift (4 P.M. to 12 P.M.)	Night Shift (12 P.M.-7 A.M.) (April 13th)
Underground		88	55	Bodies removed by 1 A.M. on April 15th
Surface		35	5	
Total		123	58	
West 8	All Underground.	20	14(Escaped)	No production.
No. 4 Bed		2	2(")	
Morgan Bed		27	14(")	
Douty No.8		23	17(killed)	
Others		16	6(escaped)	?

OPENINGS

It is stated that the two main return airways constitute the only other escapeways to the surface in addition to the main haulage-way and intake airway. Some air intakes through a caved section in the 3 B rock tunnel area.

The mine is opened by a water level crosscut tunnel and a slope dipping 30 degrees, sunk on the Bruiser (No. 5) seam from the water level. The slope entrance has an approximate vertical cover of 400 feet, the elevation at the top of the slope being 790 feet above sea level, while the slope bottom is 429 foot elevation. The slope is single track

and 700 feet long. The top of the slope is located about one-half mile underground from the portal of the mine and is reached by the above-mentioned crosscut rock tunnel 2000 feet in length and approximately 640 feet of water level gangway used for a top landing in the Bruiser seam.

The men walk in and out of the mine between shifts along the main haulage way where trolley locomotives are used from the top of the main slope to the mine entrance. The electricity is cut off the 500 volt d. c. system for about one-half hour between each shift to remove any contact hazards.

The seams are on heavy dips, and everything between the immediate roof and floor is removed in mining operations, which necessitates the removal of refuse by hand picking and washing at the cleaning plant. The washery reject averages from 30 to 40 per cent of the mine-run product.

COAL BEDS

The Carbonado field contains 12 known workable beds that have been worked at some time or other during the operation of the Carbonado mines. Very steep dips are common, the average being 60°.

At the time of the explosion but three of these beds were being worked at Carbonado, viz: Morgan, No. 4, and No. 8 beds.

Complete descriptions and composite seam sample analyses of these are given in the Mine Inspection report made by E. H. Denny and S. H. Ash in April, 1929.

The Morgan seam is a large variable seam, which varies from 17 to 18 feet in thickness between walls.

The No. 4 seam is a comparatively thick seam, varying from 8 to 9 feet in thickness between walls.

The No. 8 seam is worked in two districts of the mine situated at a considerable distance from each other. These districts are known as West 8 and Douty No. 8.

Inasmuch as it was in the working of this seam that the disaster occurred, its general characteristics are given.

The No. 8 seam is from 8 to 9 feet in thickness. The coal contains numerous bands of bony and shale, which disintegrate in handling and are removed at the cleaning plant. The coal is fairly clean, is one of the best coking seams worked in the field, and, owing to its comparatively good walls, requires less timbering than in most instances. In general, and when the dip is steep, the immediate roof in the chutes and crosscuts is the top coal. In most instances about 5 feet of the bottom section of the seam is removed in the chutes. This coal makes a good roof at the time of driving but must be timbered owing to the fact that it readily loosens up and hence would have to be later timbered. The entire seam, including any top coal left in while driving the chutes, is always removed in the pillars. The seam has a dangerous cap rock of sandy shale varying from 2 to 4 inches in thickness. Owing to the coal height this cap rock must be taken down at the time of working in the pillar workings. The main roof of massive

sandstone is timbered with single stick props and cap pieces. The gangways are usually timbered with sets placed on 6 ft. centers. The immediate floor is sandy shale, usually hard and smooth, but sometimes shelly and friable. In the area being worked in West 8 the coal lies on a comparatively light dip of 16 to 25 degrees. Sheet iron and water are used to convey the coal to the gangway, thereby lessening the coal dust hazard. In the Douty area the No. 8 seam has a dip of about 30°, and no water was being used at the time of the disaster to convey the coal in the chutes. Both faults and rolls are frequent. Three face samples of the No. 8 seam were taken in April, 1929, at the time of the examination of the mine, and one was taken on April 17, 1930.

In the Douty No. 8 area, where the disaster occurred, the entire seam is being removed in the pitch workings, and until very recently in the gangways, which makes the gangway very high on the chute side. The practice of driving with square sets has been adopted in the south side of Douty No. 8, and it was noted that the south gangway was timbered in this manner from a point about midway between chutes 4 and 5 to the gangway face, a distance of about 90 feet. When using square sets top coal on the chute side is left up. Care must be exercised to thoroughly block the sets above the collar and lagging, or there are very apt to be gas accumulations in the space above the coal that works loose from the main roof.

Here lies the danger on the gangway if an initial explosion occurs. Sets may or may not be knocked down, but the methane is very likely to enter into the propagation of the explosion along the gangway. Accumulations of fine dust also form in these "out of sight" places, and rock-dusting is the only way to counteract this danger. Square sets have their advantages, but they also have their disadvantages from a safety standpoint in cases of explosions or fires.

The No. 8 bed in the Douty area lies in a synclinal basin, is sharply folded, friable, gassy, and has a comparatively light dip (30°) on the west limb with a steep dip on the east limb. It contains fissure gas feeders due to faulting, and has a tendency to make a large quantity of fine dry dust.

The following analyses were determined by the U. S. Bureau of Mines during the year 1929 and in April, 1930.

Composite analyses on "as received" basis of Carbonado No. 8 bed, or Wilkeson No. 2 bed.

	(Composite Sample) West No.8 (1929)	Douty No. 8 (April,1930) in No.2 chute South Side	Wilkeson No.2 (1929) Lower bench only	(April 1930) Mine-run sample at face of No.5 chute - south Gangway Douty No.8
Moisture	3.1	2.7	2.5	2.2
Volatile Matter	32.3	30.5	27.8	28.2
Fixed Carbon	49.6	54.4	56.4	48.7
Ash	15.0	12.4	13.3	20.9
Sulphur	0.5	0.6	0.5	0.4
B.t.u	12,340	12,620	12,820	11,480
Volatile ratio	0.3945	0.3592	0.3300	0.3667

It will be noticed that the volatile ratio of this coal is high. The explosibility of the coal dust is well known. There is no doubt that dust is a very important factor that has to be guarded against if a repetition of such a disaster is to be avoided.

Since the latter part of the year 1925, 22 men have lost their lives because of the explosibility of the dust from this particular bed, and in this particular portion of the field. This is discussed later.

The following detailed section was taken in No. 2 chute about 90 feet from the Douty south side gangway, and is included in the foregoing analysis.

Main roof: massive sandstone

Immediate roof; sandy shale - 4 in.

		Feet	Inches
	* Soft carb. shale		3/4
	Coal	5	
	* Shale, carb.	2	
	Coal	10	
	Coal, bony streaks	4	
	* Shale, carb.		1/2
	Coal	3	1/2
	* Bone		3/4
	Coal	3	
	* Soft carb. shale		1/4
Hand Mining done in this section	Bony	4	
	* Bone		1/2
	Coal	1	
	* Bone	1	
	Coal	2	
	* Carb. shale and bone	1	1/2
	Coal	2	1/2
	* Bone		1/2
	Coal	3	
	* Bone and shale	2	
	Coal	6	

* Not included in sample.

	Feet	Inches
* Shale and bone		2
Coal		6 1/2
* Bone		1/2
Coal		3/4
* Bone		1
Coal		6 1/2
* Shale		2
Coal		2
* Bone		3/4
Coal, soft	1	5
* Soft, flaky carb. shale		8
Sandstone foot wall		
	8 Ft	4 3/4 in.

* Not included in sample.

METHODS OF MINING

The Carbonado Mine, as previously stated, is working three seams from the present slope on the Bruiser seam. The area being worked from the present slope is that included in the East Carbonado synclinal basin, dipping northwesterly and lying north of the Willis and south of the Mensie's faults, and the west limb of Douty No. 8 syncline north of the Mensie's fault. This is where the disaster occurred.

A landing has been made at the bottom of the first slope level, by driving a rock tunnel in the hanging wall directly ahead and practically in line with the slope. This tunnel intersects the No. 8 seam in about 400 feet and approximately at the axis of the syncline. At this point two gangways have been driven easterly and westerly on No. 8 seam. The workings on the north limb of the syncline or east

gangway are finished, while the workings on the west 8 gangway are now confined to drawing stumps in the light dipping area or south limb of the syncline. This gangway on No. 8 Seam was worked inby by the chute and pillar system, and because of the dip of 20 to 30 degrees the coal is washed down the chutes by water.

The main rock tunnel is continued ahead from the No. 8 intersection, crossing the axis of the syncline and crosscutting the Bruiser and underlying measures of the north limb of the syncline. This tunnel cuts the No. 4 seam at about 800 feet from the slope bottom, and the Morgan , which is the underlying seam of the present workings, at about 970 feet from the slope bottom. This tunnel requires no timber, is wet, and forms an excellent barrier for prevention of dust accumulations and propagation of a dust explosion to the slope or to another seam, in case such an explosion should occur. This was clearly demonstrated at the time of the recent disaster when the explosion traversed a portion of this tunnel.

A gangway is now being driven easterly on the No. 4 seam and is advanced about 20 chutes, a distance of about 1500 feet. This seam is being worked inby by the chute and pillar system.

A gangway was driven on the Morgan seam in two sections, and is now stopped at 36 chute, a distance of about 2200 feet. The section from the main rock tunnel is finished. The second section is connected to No. 4 gangway at 16 chute by a rock tunnel. The seam is being worked inby by the chute and pillar system.

The rock tunnel, 970 feet long from the slope bottom to the Morgan seam, was recently extended directly ahead 515 feet through a fault known as the Menzie's fault, and crosscut the No. 8 seam on the west limb of the Douty syncline. Gangways have been driven north and south for a distance of about 350 feet on either side of the rock tunnel. It is in this district where the disaster occurred. The seam is being worked advancing by the chute and pillar system.

In all seams the general practice is to work advancing, carrying the airway, known as the first counter, about 50 feet above the gangway. This counter is connected with a counter rock tunnel driven parallel to the main crosscut tunnel. The first counters of the gangways, driven in the coal seam, are connected with the gangway by means of chutes driven up the pitch 8 feet wide on 50 to 60 ft. centers. Two men work in each chute on each shift. These chutes are continued up the pitch on the full dip, and crosscuts of about 16 sq. ft. in cross-section are driven on 50 ft. centers. The chutes are usually driven on the bottom benches of the coal beds, and of such a height as to require posts about 5 to 6 feet long, the top coal being removed in the pillar workings. The pillars are extracted as soon as the chutes are driven their limit. Gangways are usually laid out at about 500 feet intervals on the pitch, the chain pillars left being from 50 to 150 feet in length.

With the exception of the Douty section, where the explosion occurred, "solid shooting" was the blasting practice.

In the Douty No. 8 seam workings where the explosion occurred, all faces were hand mined in the clear for a distance of at least 6 feet.

There are no mechanical loaders or conveyors used in this mine.

With the exception of the rock tunnels extensive timbering is required in all portions of the mine, including the gangways, which are timbered with large sets on 6 foot centers and lagged.

VENTILATION AND GASES

The mine is equipped with two fans operated exhausting and located on the surface. They are run continuously and are never slowed down. The main fan is set over the Bruiser slope return airway, which is about 1750 feet in length to the slope landing on the First Slope Level. About 1000 feet of this airway is driven from the water level to the surface. The main fan is a No. 19 Sirocco, of rated capacity of 200,000 cu. ft. per minute at a 3 inch water gage. It is belt driven by an Allis Chalmers 2300 volt, 175 H. P. induction motor, and is housed in a well constructed concrete building with wire-screened windows. The recording gauge showed a 3.8" water gauge at the time of the disaster. Explosion doors are provided and the fan is a double inlet, reversible type. The fan was not affected

by the explosion. Brush and timber are cleared away to a safe distance from the building, and a water line is located outside of the building. The connection of the fan to the return airway is of concrete. This fan tends to operate on the entire mine but is not handling all of the return air from the west workings of the No. 8 seam, some of which is handled by the auxiliary fan placed on the surface over an airway driven on the No. 10 seam. The No. 10 fan when in operation also keeps down the possibility of methane reaching the main intake airway from a possible gas area. It was manufactured by the Western Blower Company, and exhausts about 10,000 cubic feet of air per minute.

The Carbonado Mine is classed as a gassy mine by the State Inspection Department.

The large Sirocco fan at the time when the last air readings were taken, April 10, 1930, was exhausting 49245 cubic feet of air per minute from the slope workings of the mine.

There are four splits of air. Several overcasts are used and these are in solid rock. Permanent stoppings are of concrete, or wooden blocks faced with concrete. A large number of doors are used in the mine, none of which are on the haulage roads.

The general practice is to carry the air inby to the last pair of chutes which are left open. The air then passes up the manways of the chutes, which are divided into two compartments, the manway and coal side, by means of a line brattice of boards built to the roof in dips above

35 degrees. In dips less than 35° the line brattice, from the last open crosscut to the face, is made of chute boards for a height of 4 feet from the floor, and of canvas above the boards to the roof. The ventilating air current after passing the face of the inside chute passes through the top crosscut outby sweeping the faces of the chutes and entering the topmost pillar through the top crosscut of the outby chute. It then works its way down through the pillars, reaching the first counter, through which it travels to the main return.

At the time of the writers' visit the total quantity of air entering the mine was 49,056 cubic feet per minute. This was measured near the slope bottom.

Samples of the total return mine air were not taken at the time of the investigation, but readings taken in April by Denny and Ash showed the mine to be "generating" 21,051 cubic feet of CH_4 per hour, of which 16,096 cubic feet was in the main Bruiser return. It is appropriate to mention here that this was the most gassy mine in the State, as indicated by mine air samples taken during 1929 by Mr. Ash.

At the time of the writers' visit the main return air from the district where the explosion occurred was sampled and the workings where the disaster occurred were found to be "generating" 8123 cubic feet of methane per hour.

Mine air samples were taken in the returns of the Douty No. 8 Second Level Gangways north and south by means of vacuum tubes. The analyses were made at the Pittsburgh station of the U. S. Bureau of Mines, and are as follows:

Bottle No.	Lab. No.	Location in mine.	Air quantity, cubic feet per minute	Percentage CO_2	O_2	CO	CH_4	N_2	Cubic feet methane per hour	Relative humidity
133	52326	On gangway 18' inby No. 4 chute - 2nd Level South - Douty. Taken 2' from roof.		0.14	20.56		0.80	78.50		93
134	52327	In South Counter Douty 32' Outby No. 4 chute.	4140	0.10	20.51		1.08	78.31	2683	93
155	52330	Return from South side of Douty - 2nd Level at regulator in counter between 1 & 2 chutes.	10,800	0.12	20.60		0.94	78.34	6091	92
156	52331	Return from north side of Douty - 2nd Level at regulator in counter between 1 & 2 chutes.	8627	0.15	20.72		0.62	78.51	3209	92
149) 150)	52328 52329	Main return from Douty workings 2nd Level	18,050	(0.17 (0.16	20.63 20.63		0.74 0.75	78.46) 78.46)	8123	92

DISCUSSION OF SAMPLES

A study of the foregoing analyses shows that the Douty Section is DECIDEDLY gassy. The Bureau of Mines recommends that the methane content be kept below 0.25% in any split or air current. IN THIS MINE.

The sample (52326) was taken about two feet from the roof, 18 feet inside of No. 4 Chute on the south gangway of the Douty. The roof sloped upward from this point and for about 12 feet inside of this point toward No. 4 Chute, and any gas accumulation could not result as it would move, owing to its lightness, toward No. 4 Chute, up which 4140 cubic feet of air per minute was passing. It will be noted this sample contained .8 of 1% methane. This, mixed with coal dust, would make a highly explosive mixture. From the point about 30 feet inside of No. 4 Chute, where the square set timbering begins, gas was detected with the safety lamp all the way into the gangway face, and up to the face of No. 5 Chute south, at the time of the visit, although the compressed air was blowing at the face of No. 5 Chute.

A sample representing the mine air passing No. 4 Chute on the south side is represented by Laboratory No. 52327. The analysis shows that 44.7 cubic feet of methane per minute was being "generated" inside of this point, or 2683 cubic feet per hour. This was practically coming from the area in which the explosion occurred. Mine air containing this amount of gas, combined with the dry coal dust, such as could have existed at the time of the explosion in No. 5 Chute, would make a very explosive condition. If for any reason whatsoever the booster fan or compressed air was shut down a very serious condition would almost immediately arise.

Referring to Laboratory No. 52330, it will be noticed that the south side of the Douty, with only one chute working above the counter, was "generating" 101.5 cubic feet of methane per minute, or 6091 cubic feet of methane per hour. The air reading taken at the regulator between one and two chute south, where this sample was taken, gave 10800 cubic feet of air per minute, which was considerably in excess of the air measurements taken on the 9th of April at this regulator - the readings at that time showing 5180 cubic feet of air passing this point. The anemometer was checked against the anemometer at the mine, and although the anemometer was reading slightly higher, it would not compensate for this large difference. The writers were able to detect a cap with a flame safety lamp, and the reading of .94 of 1% CH_4 verifies this.

Referring to Laboratory No. 52331. This sample represents the air returning from the north side of the Douty, and indicates 53.5 cubic feet of CH_4 per minute, or 3209 cubic feet of CH_4 per hour. It will be noted that the south side is "generating" nearly twice as much methane, although fewer places are opened.

A reading of the main return air from the Douty represented by samples 52328 and 52329 shows that the Douty seam was generating 135.4 cubic feet of methane per minute, or 8123 cubic feet of methane per hour. This should equal the amount obtained by adding that from the two returns mentioned above. This summation is 9300 cubic feet per hour. Under the circumstances this checks very close, and it can be reasonably assumed that the area is "making" 9000 cubic feet of methane per hour.

The main return at the time of visit was 18050 cubic feet of air per minute, as compared with about 10000 taken on April 9th. At the time of visit the mine was intaking inside of the main slope landing 49056 cubic feet of air per minute; while on April 10th the mine was intaking, according to the mine reading, 47040 cubic feet of air per minute. This would indicate that more air was being diverted to the Douty section at the time of the writers' visit.

HAULAGE

All haulage in the Carbonado mines is placed on the intake air.

Underground haulage is by trolley locomotive and electric hoists; one 10-ton main line haulage locomotive takes the cars from the parting at the top of the slope to the cleaning plant in trips of from 25 to 30 cars. Ten gathering locomotives, viz: four 6-ton, two 8-ton, and four 5-ton, are used for gathering the coal and transporting timber. A 10-ton motor is used for extra duty and kept in reserve to replace the main haulage line locomotive in case of emergency. The locomotices are of the General Electric, Westinghouse and Jeffrey types, voltage in the mine being 500 volts.

Four small portable electric hoists using A. C. current at 440 volts are used for hoisting timber and supplies from the gangways to the pitch workings. An unbalanced 800 H. P. electric hoist placed

underground is driven by a 2200 volt induction motor and hoists coal from the slope workings in five car trips.

The coal is transported in tight-end wooden cars of 60 cubic feet capacity. Cars are not topped and the coal as loaded from the chutes is often damp, and in some cases wet, due to water being used to convey the coal from the working faces to the cars on the gangway, with the result that the main roadbeds are damp, or, as in the case of the West 8 gangway, water covers the track to the extent of filling it with fine wet coal. The track gauge is 36 inches, the rail weight being 56 pounds on the water level main haul, and 30 to 40 pounds in the gangways. The roadbeds are maintained in good condition.

LIGHTING

All underground employees use the Edison electric cap lamp, approved type, and fire bosses, shot lighters and other mine officials carry unlocked flame safety lamps of the Koehler & Wolf type. The main haulage-way and landings are well lighted with 110 volt incandescent lamps placed at frequent intervals. The gangways are not lighted.

It is the general practice in the Washington mines for officials to carry unlocked safety lamps. This practice has come about on account of the use of fuse and caps for blasting. In order to avoid lighting the fuse with matches, or from the lamp flame, the fuse is ignited by what is commonly called "touch paper"[1], which is a piece of

[1] Circular 6067, Touch Paper, by D. J. Parker, (1928)

cardboard or lamp cotton previously dipped in a solution of saltpeter and water. This is dried and carried about by the shot firers, to be lighted from within the safety lamp and used as the occasion requires. Coal mining history is filled with instances of disasters caused by opened safety lamps, oftentimes in the hands of responsible persons. For this reason the practice of allowing any unlocked lamps outside of a safe lighting station, preferably outside of the mine, is dangerous practice.

The haulage locomotives carried the usual headlights, which were in good condition as far as observed.

MACHINERY UNDERGROUND

The underground electrical equipment used in the Carbonado mine, in addition to trolley locomotives, includes several underground auxiliary fans used for ventilating beyond the last open chute when advancing the gangways, and chutes to the counter. Two transformers for lights and for switchboard control are placed in the hoist room of the main hoist at the top of the "Bruiser" slope. The hoist room is of wooden construction throughout. The manway for the slope workings is in the main return and is provided with a good ladderway. In addition to the equipment mentioned, a pump room of wooden construction throughout is located on the main intake near the slope bottom. Four Allis-Chalmers 6 stage, centrifugal pumps are located here. These are driven by four, direct- connected, 2300-volt induction motors. Three transformers and a small auxiliary air compressor driven by a 100 H. P., 2300-

volt induction motor, are installed in a chamber off the main rock tunnel. This transformer bank is used to step down the current from 2300 volts to 440 volts, and energy is supplied to the booster fans and timber hoists.

The 2300 volt power line is a 3-conductor, steel-sheathed, lead-covered cable, marine type. It is taken into the mine through the main return from the Sirocco fan to the hoist room, and from the hoist room (on the water level) to the bottom of the slope, thence to the pump room. It is suspended with straps. A branch line of this cable is carried to the inside transformer station already mentioned.

EXPLOSIVES

With the exception of the Douty No. 8 workings, where the disaster occurred, the coal is not cut or sheared in the Carbonado Mine, solid shooting being practiced. Permissible explosive, Coalite G, 1-1/4 x 8" L. F., is used in the coal and gelatine dynamite 40 and 60 per cent is used in rock work. A considerable amount of rock work is done in tunnels and driving through faults. Electric detonators are used to blast in the gangways, rock tunnels, and chutes below the counter (temporary chutes). Prior to the recent explosion these were connected in parallel and fired from the 500 volt D. C. trolley circuit at any time during the working shift. Five delay detonators were used and 5 to 12 holes fired at one time in the gangway. No general rule as to quantity of explosive per hole was observed, but it is stated that from two to five sticks (1-1/4" x 8")

were generally used. The legs of the electric detonators are of copper and are 'shorted.' The principal reason for using electric blasting in these particular cases only is to protect against misfires, as all of this work, with the exception of No. 4 gangway, is triple shifted. Blasting is done by eight shot-firers at any time during the working shift. These are all certified men. Blasting on the pitch is all "on the solid" except in the Douty No. 8, as stated above. Permissible explosive with fuse and "caps" was used in all seams in the workings above the counter. From three to five holes are lighted at one time in the chutes, when the holes are placed on the solid and four to five sticks of explosive are used in each hole. These holes are said to be inspected before the explosive is placed in the hole, and clay stemming is used, being tamped by means of a wooden tamping stick. It is doubtful if the limit to the permissible charge of 1-1/2 pounds per hole was adhered to excepting in the pillar work, and in Douty No. 8 seam where the coal was mined, and the fireboss saw the hole loaded and tamped. From two to three tamping bags with clay stemming are used which would leave 2 feet of the 6 feet holes left untamped. Examination of the working place is supposed to be made by the shot-firer before he lights any shots. The method of lighting the fuse with touch paper has been discussed.

In all electric blasting the shots are connected in parallel, the leads being connected by bare No. 22 copper wire. Number 14 R. C. wire was used as a blasting cable up to a certain point, but the lead

wire in general for about 50 feet is No. 20 Dupont leading wire. The delay caps are of all varieties, with legs 'shorted." The Atlas type were being used in the Douty No. 8 section. This is discussed later.

DRAINAGE

The Carbonado Mine as a whole is naturally damp, wet in places, while in others it is dry, as discussed under "Dust". Humidity readings, although high, indicate that the mine air, except in few instances, is not saturated. (See inspection report made in April.)

The mine "makes" considerable water which is handled by electric pumps, as has been described.

DUST AND ROCK-DUSTING

No samples of mine dust were taken for the reason that from the recent disaster and from past history in this field, it is well known that the dust will propagate an explosion. The relative humidity of the mine air, as shown in the table on page 19, is generally quite high, but dangerous accumulations of dry dust were noticed at the time of this visit in the counter of Douty No. 6 and the main slope return. Similar conditions existed in April in No. 4 and Morgan seams.

Rock-dusting has not been done in this mine. Rock-dusting of the main return, slope, gangways and counters in seams where there is any dust whatsoever, and in any accessible part of the mine not actually wet, will go far towards preventing the propagation of an explosion should there be an accidental ignition of gas, or an experience

similar to the recent disaster.

The volatile ratio of the coal seams at Carbonado are such as to make the coal dust highly explosive. They are as follows: Morgan Seam 0.3775; No. 4 Seam 0.3777; West No. 8 Seam 0.3945, and Douty No. 8 Seam 0.3592. This ratio is an index of the explosibility of the coal dust. Explosibility increases rapidly between the ratios 0.14 and 0.25, remains constant between the ratios 0.26 and 0.40, and then increases slowly. Experiments performed by the Bureau of Mines would indicate that 61 per cent of incombustible would be required to make the dust of the Carbonado coals non-explosive when no gas is present. For every one per cent of gas present the rock dust would have to be increased approximately 8 per cent. The long wet rock tunnels, as has been stated, provide an excellent second line of defense, but rock-dusting carried to the gangways, counters and chutes should form the first line of defense. Samples of dust should be taken from time to time and the percentage of incombustible in the dry sections kept above 65 per cent.

CONDITIONS IMMEDIATELY PRIOR TO DISASTER

No record is kept at the mine of barometer readings.

The following readings are as reported by the Weather Bureau at 5:00 P.M. at Seattle. The weather had not been stormy and these readings would indicate general conditions at Carbonado, immediately

before and after the recent explosion.

April 11	29.97		Falling barometer
12	29.88	Explosion 5:30 P. M.	
13	29.63		
14	29.80		
15	30.13		Rising barometer
16	30.16		
17	30.04		
18	30.04		About normal

Readings reduced to sea level.

The fan was running normally as indicated by the recording gauge charts, and developing 3.8 inches of water gage.

The latest fireboss report stated the working places were clear, and verbal statements to the writers were that no gas was found the day of the disaster.

The mine was working normally on the day of the disaster.

The last fireboss record reporting gas was on March 23, 1930, as follows: "GAS IN SOUTH COUNTER DOUPY NO. 2 CHUTE." W. Mataya.

PREVIOUS EXPLOSIONS AT THIS AND NEARBY MINES WITH LOSS OF LIFE.

Date	Mine	Cause	Fatalities
Dec.9,1899	Carbonado No. 7 Mine (No. 4 Seam)	Record not available.	31
Feb.17,1923	Carbonado (South 6)	Blasting one shot at a time electrically. Edison battery used. Windy shot on second blast by fireboss. Permissible explosive used. Very similar to disaster of Apr. 12, 1930. Gangway and pitch wet. Counter very dry.	4
DEC. 17, 1924	BURNETT MINE	(GAS IGNITION BY TROLLEY LOCOMOTIVE IN SECTION VENTILATED BY BOOSTER FAN)	1
Dec.14,1925	Wilkeson Mine Carbonado Douty No. 8 Seam (Wilkeson 2)	Dust explosion caused by bull-dozing. Mine classed as WET.	5

EXPLOSIONS AND GAS IGNITIONS WITHOUT FATALITIES

Date	Mine	Cause	Nature of Injuries
Nov.14,1927	Carbonado (Present Mine)	Gas explosion caused by trolley locomotive igniting gas at top of Bruiser slope	Five men injured by burns, one of whom died.
Dec.1,1927	Carbonado Water level haulage-way (Present Mine)	Gas explosion caused by trolley locomotive	One man burned.
July 16,1929	Carbonado West 8 (Present Mine)	Gas ignition firing shots with touch paper, fuse and caps.	No injuries. Mine fire.
Aug.22,1929	Do	Gas explosion. Reopening sealed fire area.	No injuries. Seals replaced and mine recovered Oct. 16, 1929.

PROPERTY DAMAGE

The property damage caused by the explosion was relatively slight on account of the small area involved. Board stoppings were blown out in some of the chutes between the Douty 8 gangways and first counter,. and one stopping between the rock tunnel and main return near the Douty No. 8 workings was also blown out. Work was resumed in the mine proper on April 17th, but not until April 21, 1929, in the Douty No. 8. Water lines had been put in, and the roof, ribs, timbers, etc. thoroughly washed to remove the dust.

FORCES.

Considerable force was evidenced between No. 3 and No. 4 chutes on the south side adjacent No. 5 chute, where it is believed the initial explosion occurred. Force is evident at No. 3 chute on the north side, where the cars were moved. There was little evidence of force in the south counter except that men in No. 2 chute South were shocked and probably hurled against face. The force in north counter was slight. There was no evidence of force at the face of the North Gangway. The force at No. 3 chute South upturned the booster fan located there. The fan, although found turned upside down, was running when rescuers entered. The current had not been cut off the section after the explosion occurred. This in itself was a dangerous situation.

The force was sufficient to open a door between the main return airway and the slope at the bottom landing. The maximum force was evident in the main intake rock tunnel, where 12 x 12" x 6' timbers were blown or scattered from a point (A) (see Map), about 150 feet from gangway to a point (B) outby in the main haulage rock tunnel, a distance of nearly 1000 feet. A stopping at point "A" was blown out. A large galvanized iron air pipe in the rock tunnel airway between the Douty and the Morgan seams was flattened but not blown down. But two of the bodies showed unusual violence. These were on the gangway, one at No. 3 chute North and one at No. 3 chute South.

EVIDENCES OF HEAT OR FLAME

The undertaker was interviewed by Mr. R. W. Smith, Chief Mining Engineer of the Pacific Coast Coal Co., and S. H. Ash, and the following table shows his statement, and verified by others, regarding the conditions of the bodies with respect to shock, burns and asphyxiation evidence (CO).

Number on Map	Name	Condition of body and probable cause of death
1	David Hughes	Badly burned and shock
2	Vic Pete	" " " bruised
3	Al. Parkins	Burned and shock
4	R. C. Legge	" " "
5	Mike Sheridan	" " "
6	John Bates	Bruised and asphyxiated. No burns.
7	John O'Leary	Asphyxiated. No burns,
8	P. Fleis	" " "
9	Wm. Kennedy	Asphyxiated; no burns. No bruises. Body showed no sign of violence.
10	L.B.O'Neal	Asphyxiated. No burns or shock.
11	John Flood	Asphyxiated. Very good shape. No burns.
12	Wm. Matson	No burns. Concussion. Evidence of falling down chute.
13	Wm. McMurphy	Badly burned and broken. No asphyxiation.
14	Ed. Woli	No burns. Asphyxiation. No shock.
15	Silvester Barker	" " " " "
16	Ray Glackin	" " " " " } Very good shape.
17	Thomas Shackley	" " " " " }

Timbers from chute 5 on the south side to chute 5 on the north side showed some evidences of charring. It was most pronounced at No. 3 chute North, where McMurphy was found badly burned. There was no charring nor coking evident in the counter on either side or in the main return

rock tunnel, which is heavily timbered and dry near the affected district. The main haulage rock tunnel is only timbered in spots, was very wet and showed no evidence of charring.

Coal dust was coked to some depth on the inby side of timbers at No. 3 chute North. Coke was on the inby side of timbers on the north side diminishing inby from No. 3 to No. 5 chute North, and outby from No. 3 chute North to the rock tunnel junction. Coke was also on the outby side of timbers from No. 5 South to the junction, but not to the same degree as at No. 3 North. The counters showed considerable dust and are dry.

The explosion died near the West 8 junction, about 1000 feet from the junction of the Douty No. 8 seam and main rock tunnel. This was caused by the wetness of the main rock tunnel and opportunity for expansion in the Morgan and No. 4 seam workings.

SAMPLES

Samples of coal, mine air, and explosives were taken by the writers. The coal and mine air samples have been discussed.

No samples were taken of road, rib, roof and timber dust. Any dust is coal dust, for as stated there is no rock dusting done at this mine.

A sample (20 sticks) of the explosive used in the district where the explosion occurred, was taken in the counter between No. 2 and No. 3 chutes North. Twenty sticks were also taken from the surface

magazine, from what was stated to be the same lot of explosive. These samples were sent to the Pittsburgh laboratory.

This explosive was Coalite G, permissible, manufactured by the Giant Powder Company. Sticks were 1-1/4" x 8" L. F. The lot number was No. 3 - 652.

No samples of detonators used were taken. Those said to have been used were manufactured by the Atlas Powder Company, Wilmington, Delaware. The delays used are 12 ft. - No. 8 - copper leads, Nos. 0 to 5.

No samples of fuse or "caps" were taken. These are triple tape and No. 8 DETONATORS.

STATE INSPECTOR'S CONCLUSIONS

The following paragraphs are taken from report of Mr. Wm. Reese, State Mine Inspector:

"Assisted in our investigation by the most eminent coal mining men of the State, after due deliberation we were brought to the conclusion that the origin of the explosion was in No. 5 chute of the south gangway and the cause as firing two coal shots in the face of that chute. Evidence has conclusively established the fact that no shots were fired except in that chute in this section of the mine at the time of the catastrophe. Furthermore, the men's bodies found after the explosion in the vicinity of No. 5 chute were all burned

severely, while those in the pitch and on the north side of the mine did not show but little if any signs of scorching and undoubtedly were killed by "after damp" and the concussion of the blast.

"The firing switch was located a little distance inside of No. 3 chute and Hughes evidently following this practice threw in the switch, as his body with five (four checked by writers) more of the miners was laying at the immediate locality of the firing switch. Delay electric detonators were used, and when Hughes, foreman in charge, threw in the switch the interval between the explosions was several seconds, and as the charge of powder in the first hole going off was greatly in excess of what was required, pulverized the coal into dust, charging the atmosphere with an element capable of the havoc and destruction wrought even had there been no gas present. It is not conceivable that Hughes failed to examine for gas before either charging or firing the holes as all testimony of the witnesses examined declared him to be a most thoroughly careful foreman, particularly in the matter of gas and the handling of explosives."

SUMMARY OF EVIDENCE AS TO CAUSE, ORIGIN, AND PROPAGATION.

An examination of the face of No. 5 chute South shows a condition, evidenced by two holes partly standing in undercut portions of a friable coal bed, that the shots were overloaded, that either one was capable of doing the work intended for two, and that the right-hand shot probably went off first. Whether the delay "cap" used for the second shot was a first or a fifth delay nobody knows. The probable condition of the face and location of the holes is shown on sketch in the appendix, together with a diagram showing face details at time of writers' visit. Evidence points conclusively that a windy shot resulted. There is no data available to determine the quantity of explosive used as no record is kept of the number of shots blasted.

The blasting was done off a power circuit, which was the trolley line carrying 500 volts D. C. The main blasting line was a two-wire, No. 14, rubber-covered, copper wire, which normally is led to about 50 feet from the face. A blasting line consisting of two wires of Dupont No. 20 connecting wire is led from the No. 14 line to the face. The shots are fired in parallel, and the lead wires attached to a two-wire bus made of two No. 22 bare copper wires. The bus wires are attached to the connecting wire.

In this instance, however, a new blasting line of two No. 14 R. C. copper wire had been put in and led to the face instead of the No. 20 connecting wire. The assistant foreman on the day shift (S. Smith) stated this was not in when he left at the close of the day shift, and the conclusion was reached that trouble had been experienced when blasting was first attempted and a heavier line was put in. There was no evidence of charring of this blasting line.

The deceased night foreman, Mr. Hughes, was a man of long experience, whose reputation was that of a careful, conscientious man. That he tested for gas cannot be doubted, and that he found the face clear no one will question. The chute was ventilated by compressed air and air from a 12" Flexoid tubing led from a booster fan located about 150 feet from Chute 5.

The coal bed is removed for its total height (8 to 9 feet), and the gangway timbered with square sets at Chute No. 5 South. There is a "jog" in the roof of the chute where the chute connects with the gangway, caused by the top coal being left up in the gangway, but taken down in the chute. On account of the large area of the chute, low velocity of the return air, height of the chute (10 ft. props are used) it is possible to have gas, not necessarily explosive, in the area back from the face, that a fire boss would not detect unless he tested the air all the way up the chute, and to reach the high spots a ladder

or staging is almost a necessity. That there may have been some gas in the deep mining at the face of the chute is not impossible. Without assistance one man would have difficulty in testing for gas at the face of the mining on this pitch.

That the air in No. 5 Chute was heavily laden with a large quantity of fine dry dust is very probable. The reasons for this are that the coal is exceptionally friable and dry; the small volume of air returning through an area of about 70 square feet in the chute contracting to about 40 square feet at the chute entrance; the distance of the face from the gangway (33 feet before blasting); the fact that at least two 6-foot holes had been drilled dry with a jack hammer just prior to the blasting. At the time of the writers' visit, just walking in the chute created a very dusty condition.

A study of the barometer readings previously given shows a rapidly falling barometer at the time of the disaster, and more gas would be liberated. That methane, not detectable with a safety lamp, was present in the return air cannot be questioned. Although gas has not been reported in the working faces, it was detectable with a safety lamp at two known points for some time. These two points are gas feeders in the counter, one of which is 11 feet outby No. 4 Chute South, the last chute 'holed,' and adjacent the No. 5 Chute South being driven.

The south counter had been idle for over a week and would not be considered a working place. It is driven 50 feet inby No. 4 Chute South. Compressed air only was used for ventilating this place, and at the time of the writers' visit was not sufficient to thoroughly dilute the gas back from the counter face to No. 4 Chute. Although the compressed air was running normally and steadily since Sunday, a larger quantity of air was being circulated on Thursday and passing No. 4 Chute outby to No. 3 South in the counter (4140 cubic feet per minute, as against 3000 on April 9, 1930, when last air readings were taken); the writers found this counter full of gas and it could not be entered on Thursday. As stated, this place had not been worked for a week, and the barometer readings show a rising barometer between the time of the disaster and the writers' visit. Less gas should have been given off unless a new feeder developed at the face of the South counter, although it was not worked. Gas was also observed with the safety lamp in this large volume of air along the high side of the counter roof from No. 4 Chute back to the regulator at No. 1, where 10,800 cubic feet of air per minute were passing, as against 5120 recorded on April 9.

The booster fan was not running or had not been running from the time of the disaster until the writers' visit. The compressed air was blowing at the face of No. 5 Chute South. In spite of this there was gas at the face of No. 5 and a considerable amount extending from the face of the chute and on the south gangway from No. 5 Chute to the

gangway face. This supports the fact that if for any reason whatsoever the booster fan shut down, gas would accumulate quite readily. This is not probable as the booster fan is on a separate 440 volt A. C. line. As previously stated, however, on account of the large areas of the chutes and gangway, the face could be clear and still there would be gas back from the face. In case of a windy or blown-out shot this would then enter primarily into the propagation of an explosion.

Gas was also found in the first crosscut, No. 3 Chute North, extending from the face to the chute, a distance of 26 feet. Ventilation of these crosscuts is effected by compressed air only. This place had not been cleared since the disaster, and this could be expected. Nevertheless it brings out the important facts that the bed is gassy, compressed air should not be used for ventilation, and the air should be properly coursed by brattice.

The writers examined the roof at the highest side of the large gangway extending from the square sets about 30 feet inby, No. 4 Chute South, to the face of the North gangway, and did not detect gas with a safety lamp.

It is the opinion of the writers, as well as the opinion of all who investigated the matter, that the explosion was caused by a windy shot or shots resulting in an explosion of dust, or gas, or both combined.

Open lights or matches did not enter into this disaster. A search was made for matches on April 14, 1930, and none were found. A key for unlocking Edison batteries was found on one of the deceased miners

who worked in No. 5 Chute South.

That the origin of the explosion was at the face of No. 5 Chute is evident. This is supported by the facts that blasting had not been done in any of the other places; the position of the men and condition of the faces indicates that they were timbering or mining. The position of the bodies of the South gangway men and the No. 5 Chute miners, together with the shot-firer (night foreman), further supports this. To remove any doubt whatsoever, the switch of the blasting line was found closed.

The switch used for blasting is a 30 ampere, "Enclosed Electric Switch, 500 volt, 3 pole, rating 40351, Type C," manufactured by the Trumbell Electric Company, Plainville, Connecticut.

This is not a permissible switch for use in gassy or dusty mines.

Two No. 14 R. C. wires for the blasting line were led from two terminals on the dead side of the switch. Two wires for a feed line were led from two terminals on the live side of the switch, one of which connects with the trolley wire and the other with the rail of the haulage track.

That the explosion was propagated by coal dust on the gangway is supported by the presence of coke and the large quantities of dust present after the disaster. That it did not propagate back through the main return airway, which contains a large quantity of

dust, is because of the large area of the gangway and main rock tunnel, which is wet, and along which the explosion traveled; also to the solid stoppings and long pillars between the main rock tunnel airways. The writers did not find gas on the gangway outby No. 4, but on account of the seam being gassy and the feeders mentioned, there is no doubt that gas, not necessarily detectable with a safety lamp, was present in the return air and entered into the propagation for some DISTANCE along with the dust in the South counter. On account of the greater resistance in this passage-way, the main force of the explosion was not expended in this direction, but relieved itself through the main rock tunnel.

One thing that could have caused an explosion under similar circumstances is the heated lead wires , or an electric arc from a "short" at the face, caused by using a 500 volt power circuit.

Another is the practice of delayed blasting, whether by fuse or delay detonators, as used in this recent instance. On another occasion in Carbonado South 6 in 1923, when blasting one shot at a time, electrically, with permissible explosive, the shot-firer made the mistake of either not testing for gas, or the amount of work to be done by the succeeding shot, and a similar explosion occurred.

LESSONS TO BE LEARNED FROM THIS DISASTER.

1. In a gassy or dusty mine blasting more than one shot at a time, whether by fuse or electrically, leaves too much responsibility in the hands of one man, in whose hands lies the lives of men in the mine, as well as the saving or destruction of property.

2. The use of delay detonators, even when used in conjunction with permissible explosive, is a dangerous practice in a gassy coal mine not even necessarily dusty. If dust is present the danger is immeasurably increased. Recent experiences of the Bureau of Mines have revealed the fact that miss-fires with fatal results, although not so frequent as when fuse is used, do result from the use of delay detonators.

3. Blasting in parallel from power circuits is a dangerous practice in gassy or dusty coal mines.

4. That gas should be reported whether existing at working faces, standing faces, or feeders in the active or adjacent workings.

5. That working three shifts creates the most hazardous condition as it relates to gas being liberated and the presence of suspended coal dust.

6. That the use of compressed air for ventilation may not be keep the face clear but it by no means insures the fact that there is not a dangerous mixture of air, methane and dust in the area outby from the face.

7. That all shots should be tamped and loaded by the shot-firer and not by a miner, supposedly in the presence of the fire boss. It leaves too much chance for overloading the holes. IF THE MINER CHARGES THE EXPLOSIVE BEFORE THE COMING OF THE SHOTFIRER.

8. That drilling dry with jack hammers, of from 2 to 5 holes, creates a very dangerous situation as regards finely suspended coal dust.

9. That ventilation other than by proper coursing of the air by brattice is not to be relied upon. The proper coursing of the air is a vital factor in coal mining from both the safety and mining standpoint.

10. That supplementing good ventilation comes the most important matter of making it impossible to ignite coal dust or methane in explosive percentages, or an explosive atmosphere made so by the presence of methane and dust. There is no longer any question as to the remedy. It is rock dust, placed in sufficient quantities on ribs, timbers, roof and floor in all underground passage-ways, and backed up by efficient rock-dust barriers at critical points. Water should also be used at the face. The use of water at the face will keep down the quantity of coal dust, but will not prevent the accumulation of dangerous dust on the timbers and places of lodgement back of the face, and caused by loading.

11. That dust explosions result in mines that are supposedly wet.

12. That wet gangways and rock tunnels form an excellent line of second defense.

13. That blasting shots at any time during the day when the men are in the mine, even when done by responsible persons, sooner or later is likely to results in a disaster of some kind.

14. That quick thinking on the part of intelligent fire-bosses (Wm. Mataya) and (Harvey Hiber), in placing barricades and restoring ventilation, probably saved some lives in another section of the mine.

15. That even where the coal is mined in the clear, and a large volume of air is in circulation, explosions can occur, and that any safety practice adopted pertaining to mining and blasting in one part of the mine should be practiced in all parts of the mine.

16. That the use of trolley non-permissible haulage motors, although not a factor in this instance, may cause an initial explosion when gas accumulates during interruptions to the ventilation, or from gas feeders.

17. That a careful check and record should be kept as to the number of holes blasted and quantity of explosive used.

18. That several of the miners were on the way to safety, and if provided with self-rescuers and same had been used, although problematical, they might have effected their escape in this instance. This is discussed further.

19. That some permissible testing device other than a flame safety lamp, could be efficaciously used in testing for gas in high places, whether in the chutes or gangways. THE BURRELL OR THE U.C.C. IS SUITABLE.

20. That main compressed air lines should be buried and located in such positions that they could not be broken easily. In this particular

instance if the main compressed air line had not been broken some men in the North side might have saved themselves.

21. Although not a factor in this mine, all shot-firers should be extremely careful, conscientious, experienced men, who should be CERTIFIED. Also that before any person other than a regularly employed shot-firer, although certified, is allowed to blast shots in a mine, owing to some contingency, a notation should be made of this fact in the foreman's time book or note book, carried on his person, and the superintendent should be notified and his permission obtained before any blasting is done.

PREVENTIVE MEASURES THAT HAVE BEEN TAKEN.

1. Blasting electrically from power circuit has been discontinued in all parts of the mine.

2. All electric blasting with the exception of the gangways is to be single shot blasting, using permissible single shot blasting units.

3. All blasting on the pitch in the Douty workings will be done electrically with single shot blasting units. All shots are to be mined in the clear as at present and the face thoroughly cleared and inspected before each shot is blasted.

4. The shot-firers will load all holes in the Douty section.

5. The question was not definitely settled as to whether or not delay blasting would be done in the gangways, but in any event power or battery circuits would not be used. Blasting machines are to be used for this purpose.

6. Water lines have been extended to all working faces and the face is wetted and the coal washed down the chutes.

7. Rock-dusting of the gangways and counters is being considered.

8. Any gas in any accessible part of the mine, whether working or not, is to be reported.

RECOMMENDATIONS

To prevent a recurrence of such a disaster, in addition to what has been done:

1. Blasting should be done electrically in all parts of the mine. Single shot blasting units should be used for this purpose. Blasting, if not done when all the men are out of the mine, should be done at least with only the shot-firers present, who should load and blast all shots. There is no reason to believe that a similar disaster could not occur in the other seams.

2. Permissible explosive only should be used in all classes of work, and then in permissible amounts.

3. Where feasible, the coal should be undercut or sheared in all parts of the mine, and if more than one shot is fired at one time, after a face is properly undercut, they should be fired simultaneously. The same thing applies to pillars where the shots have ample free faces.

4. Delay detonators should not be used.

5. Fuse and caps should not be used.

6. All flame safety lamps should be permissible and magnetically locked.

7. Rock-dusting should be done in all accessible parts of the mine, not actually wet.

8. Compressed air should not be depended upon for ventilation, but the air should be properly coursed to the face by brattice.

9. If electrically driven auxiliary fans are used they should be on pure intake air, should be kept running 24 hours a day, and they should be inspected at least hourly by an official. The writers recommend compressed air driven fans if auxiliary fans are used.

10. Permissible storage-battery locomotives should be used for haulage purposes.

11. Stemming in shots should extend to the collars of the holes.

12. A record should be kept of the number of all shots fired and the quantity and kind of explosive used.

13. Analyses of return air and in the working places should be made at regular weekly intervals.

14. Frequent tests for gas should be made in high places, and back from the faces. The writers wish to call attention to the value of the permissible Burrell and U.C.C. detectors for this purpose.

15. All electric power lines should be sectionalized. Instructions should be issued to immediately cut off the power from the underground lines in case of disaster, and no switches should be cut in until it is definitely established that it is safe to do so. A second explosion at least as disastrous as the first may result in a mine if explosive gas is present, which can be caused by an electric arc when the explosion area is entered by rescuers.

ACKNOWLEDGMENTS

The writers are not unmindful of the difficult and costly conditions met with in the Carbonado mine, and of the desire and earnest efforts made by the management to make the mine as safe as possible.

This report is made with a sincere desire to assist in this effort, and the writers wish to thank Mr. H. D. Moore, Vice-President; Mr. W. A. Wilson, Manager of Mines; Mr. R. W. Smith, Chief Mining Engineer; Mr. Robert Simpson, Superintendent; and all local operating officials, for their assistance and cooperation in this investigation.

APPENDIX

USE OF BARRICADES, MINE RESCUE APPARATUS, GAS MASKS AND SELF RESCUERS

In the discussion of ways and means of preventing explosions, there is always the vital question of "what" or "what not to do" in case they happen. Fortunately, disasters do not occur with the same frequency as accidents when the latter is used in its more general terms, and the same things do not apply as when we discuss "Accident Prevention" and "First Aid", in their general sense.

At the Carbonado mine the men are 100 per cent trained in First Aid, and as part of the training in this work, more or less discussion was given to things that properly belong to the course in mine rescue. The writers believe, however, that in training a group of men in and about a mine on the cooperative first-aid plan, no better opportunity could be afforded for discussing accident prevention, whereby the total group can be reached. The goal desired is to create a state of mind toward accident prevention on the part of 100 per cent of the men, and a short time spent in discussing barricades, gas masks, self rescuers, and mine rescue equipment is time well spent, and is bound to leave some impressions that will lead to safety mindedness, in case of a mine fire or explosion.

Some very excellent work has been done in the past at this mine by the mine rescue men, and on this particular occasion this was repeated.

Mention has been made of the timely action of Wm. Mataya and Harvey Hiber, fire bosses, whereby 16 men possibly were saved, by barricading themselves quickly and methodically. Such acts do not always come to the attention of those outside of the group at the mine, and the writers desire to include this meritorious incident as showing what can and should be done at such times.

When the explosion occurred, referring to the map of the mine, a group of 14 men were employed in the Morgan Seam, and 2 men in No. 4 Gangway, under Wm. Mataya, fire boss. A group of 14 men was employed in West 8 under Harvey Hiber, fire boss.

A rush of wind warned them that something had happened, and each fire boss hurriedly got his group together, and started out to investigate.

Mataya and his group met the smoke and fumes entering the No. 4 intake, but owing to the fact that the air was short circuited by a door being opened near the slope bottom, the air current was not moving rapidly. Mataya immediately retreated with his men through the rock tunnel connecting No. 4 and Morgan seams, and erected two canvas barricades as shown. While his men were tightening up the barricades, Mataya went up into the counter or return airway, which contained the freshest air in his section. He went out along the counter to No. 17 Chute on No. 4 Seam, and short-circuited the air at this point, which left the barricades unmolested by the outside air. Compressed

air was available if it had been necessary. Mataya and his men were safe, and could observe the circulation of the air evidenced by the smoke from the Counter side. Barricades were to be placed in the Counter.

In the meantime Hiber and his men reached the junction of the main tunnel, and observed the wall of smoke a short distance inby, as it had not reached the West 8 split. Hiber found the smoke too thick to enter and realised that something had happened, either in Morgan No. 4, or the Douty sections. He also realized that the air was short circuited somewhere outside of the point where he was located. He proceeded in the fresh air to investigate, and found the door between the main intake and return at the slope bottom had been blown open. He closed this, which restored the ventilation in Morgan and No. 4. Owing to the air being short-circuited by Mataya at No. 17 Chute of No. 4 Seam, this area quickly cleared up. Hiber proceeded withthe air and joined Mataya.

Self rescuers have been mentioned in this report, and it is not an impossible thing that some of the men may have saved themselves in the Douty, if they had possessed and used them.

The use of self-rescuers and gas masks is limited, however, although they have many applications. In disasters they may be imprudently used. The men in the Douty had no show to barricade themselves, but the men in Morgan did, and they acted sensibly.

The presence of considerable coke on the gangway, with comparatively little violence, indicates that dust was a very important factor. That considerable smoke and toxic gases resulted there is no doubt. The men outside of the explosion area could not penetrate it. Experiments performed after a mine explosion, classed as a dust explosion, in the experimental mine of the Bureau of Mines, indicates that 8 per cent of CO results immediately after a dust explosion, and this is many times more than the amount that can be safely handled by any type of gas mask or self rescuer. Evidence points strongly to the fact that some of the men made considerable headway, but it was insignificant when compared to a situation where a mine would be involved. If it could be assumed that the CO content were not in excess of 1 to 2 per cent, some of the men might have effected their escape in this unusual situation, but it is more likely that the CO content was in excess of that for which such apparatus is designed.

The danger in using self rescuers and gas masks lies in going from a place of safety, such as a barricaded zone, into one of danger. No one is ever sure that an atmosphere may not be encountered that does not contain CO in excess of that which can be handled by this equipment OR AIR WITH TEMPERATURE TOO HIGH TO BE BREATHED SAFELY. For this reason men barricaded in good air should never proceed from their place of safety, until they are reasonably sure that this can be safely done.

The limitations of such equipment cannot be too fully stressed. Barricades have saved many lives, and nothing can take their place. Self rescuers would be an aid in a zone getting bad, and a possible life preserver where a barricade could not be erected, but barricades should be stressed first, last, and all the time.

The erection of barricades again brings to mind the desirability of having doors hung in rock tunnels and counters, or in openings through blind pillars, whereby sections of the mine could be quickly and effectively sealed off, should the occasion arise, as it did in this instance.

REPORT OF CHIEF MINE INSPECTOR

"REPORT OF FATAL ACCIDENTS
PACIFIC COAST COAL COMPANY - CARBONADO MINE

APRIL 12, 1930.

NAME	AGE	DEPENDENTS		OCCUPATION	NATIONALITY
Sylvaster Barker	34	Married	Wife-2 Children	Miner	American
John L. Bates	31	"	" 2 "	"	"
John E. Flood	54	"	" 4 "	"	"
Ray Glackin	36	"	" 1 "	"	"
Wm. Kennedy	25	Single	- - - - - - -	"	Scotch
R. C. Legge	32	Married	Wife 1 Child	"	American
Wm. E. McMurphy	28	"	" 1 "	Motorman	"
L. B. O'Neal	45	"	" 5 Children	Miner	"
John O'Leary	52	"	" 3 "	"	"
Alfred Parkin	38	"	" 3 "	"	"
Victor Pete	31	"	" 1 Child	"	"
Thos. J. Shackley	30	Single	- - - - - - -	"	English
David J. Hughes	48	Married	Wife 1 Child	Foreman	Welsh
Wm. Matson	42	"	" 2 Children	Miner	Finnish
Martin Sheridan	46	"	" 1 Child	"	Irish
Ed Wali	43	Widower	- - 1 "	"	Finnish
Phillip Fleis	22	Single	- - - - - - -	Loader	American

were killed by an explosion of coal dust or gas or both combined, occurring at 5:30 p. m., on date already noted in the Douty Seam of above mine.

"This is practically a new operation recently reached by a tunnel extending from the underlaying Morgan and No. 4 seams and the gangways driven about 350 feet on either side from the rock tunnel. The counter gangway parallels the main gangway and is located up the pitch about 50 feet and acts as the return air course, the main gangway being the intake, and the air current is split at the north and south fork, ventilating each side separately.

"There are five chutes driven on each side. All five on the north side were holed through to the counter, while on the south side the No. 5 chute was being holed and within fifteen feet of tapping the counter. Two shifts, one in the morning followed by one in the afternoon, comprised of a foreman, two miners in each chute, two in each gangway, two in each counter gangway, a loader and motorman, constituted the working force of the section, all of whom perished leaving no positive clue as to the origin and actual cause of the tragedy, and all conclusions must of necessity be deductions from the effect left in the ruins and path of the destructive blast.

"Assisted in our investigation by the most eminent coal mining men of the State, after due deliberations we were brought to the conclusion that the origin of the explosion was in No. 5 chute of the south gangway and the cause as firing two coal shots in the face of that chute. Evidence has conclusively established the fact that no shots were fired except in that chute in this section of the mine at the time of the

catastrophe. Furthermore, the men's bodies found after the explosion in the vicinity of No. 5 chute were all burned severely, while those in the pitch and on the north side of the mine did not show but little if any signs of scorching and undoubtedly were killed by "after damp" and the concussion of the blast.

"The practice in this seam is to mine by pick work to the depth of six feet or more the entire width of the chute, eight feet, and no shooting is permitted in the undercut. The under-cutting is done in the middle of the seam and the top is permitted to be blasted down, or the bottom shot up if need be.

"The morning shift had under-cut about eight feet but had not drilled the top holes for the reason that the air lines had broken down during the afternoon, not enabling them to do so. When the afternoon shift came to work, the pipe lines had been repaired and drilling could be undertaken, so about the first thing to be done was to put in the shot holes. Apparently two rib holes, each about six feet deep, were drilled - there was no evidence of a center hole which is sometimes necessary on account of the thickness and hardness of the top coal in places. Permissible powder and electric detonators are used in this section and the practice is for the foreman, fire boss, or shot lighter to examine for gas before the holes are charged or tamped, and if no gas is detected, the miners are allowed to charge the hole or holes, as the case may be, with explosives, and again the official present examines the place for gas, and if no gas is found, proceeds to connect the electric blasting lines and

personally throws in the firing switch.

"The firing switch was located a little distance inside of No. 3 chute and Hughes evidently following this practice threw in the switch, as his body with five more of the miners was laying at the immediate locality of the firing switch. Delay electric detonators were used, and when Hughes, foreman in charge, threw in the switch the interval between the explosions was several seconds, and as the charge of powder in the first hole going off was greatly in excess of what was required, pulverized the coal into dust, charging the atmosphere with an element capable of the havoc and destruction wrought even had there been no gas present. It is not conceivable that Hughes failed to examine for gas before either charging or firing the holes as all testimony of the witnesses examined declared him to be a most thoroughly careful foreman particularly in the manner of gas and the handling of explosives.

"After the bodies of the unfortunate victims had been removed from the mine, a party consisting of the Mine Safety Committee, mine officials, representative of the U. S. Bureau of Mines, and State mine inspectors entered the mine and made a thorough examination of the entire section effected. After returning to the surface, a large number of witnesses, who had any knowledge of conditions and practices followed in the operation of the mine, were called to testify. Again on the Tuesday following, a number of the most prominent mining men in the State and the chief mine inspector of British Columbia made a minute inspection

of the affected part of the mine, and after returning to the surface held a meeting in the mine office. Each was called on to express his personal opinion as to the origin and cause of the explosion, and to give suggestions as to preventative measures that might be taken to avoid a recurrence of such tragedies in our mines. Each responded cheerfully and the consensus of opinion was that the explosion originated in No. 5 chute on the south side and was caused by too heavy a charge of powder in the first hole going off and creating a dusty atmosphere, while possibly a small quantity of gas liberated by the first shot added the element necessary to the propagation of combined gas and coal dust explosion, when the second shot went off, capable of the havoc wrought in the destruction of life and property in its path.

"Suggestions were offered as means of minimising such occurrences by rock dusting, and the elimination of blasting, except one shot at a time, and the working place examined for gas after each blast before igniting the second charge. All such constructive suggestions were welcomed by the officials of the company, and the meeting was informed that instructions had already been given in the matter of blasting conforming with the suggestions offered, and that rock dusting had been under consideration by the officials of the company for some time in their New Black Diamond Mine, and plans formulated for carrying water lines up each chute in the Douty seam of the Carbonado Mine for the purpose of floating the

coal down each chute for the reason that the seam is not steep enough to carry the coal down on sheet iron, and if not sufficient moisture was thus dissipated in the workings to render the dust inert, the Douty seam would also be rock dusted.

The lesson - ETERNAL VIGILANCE.

SEATTLE, WASHINGTON
April 18, 1930

DEPARTMENT OF LABOR AND INDUSTRIES
DIVISION OF MINING SAFETY
By Wm. R. Reese, Chief Mine Inspector
Geo. T. Wake, Deputy Mine Inspector."

OTHER DANGERS AFTER EXPLOSIONS

At the time of the investigation it was revealed that one of the booster fans was still running, although turned upside down. Also that one of the rescuers received a slight shock by touching a fallen wire.

This instance brings to mind the extreme danger from a second explosion due to an electrical ignition. In this particular instance, because the power was not cut out of the section in this gassy area, interrupted ventilation and large quantity of fine dry dust present, a short circuit causing an electric arc, would be exceedingly dangerous.

Section line-switches should be provided, and at the time of a disaster, the current should be cut off the mine, until it is definitely ascertained that all electricity is cut out of the affected district.

In any gassy mine there are dangers from storage battery locomotives in an explosion area. Until it can be definitely ascertained that there are no fires or "shorts", there is extreme danger due to electrical ignitions.

Supervisors should be instructed as to the dangers from electrical ignitions which are causing the majority of our mine explosions.

DISCUSSION OF DECEASED MEN IN AFFECTED ZONE

It has been stated that the men killed in the Douty had no chance to barricade themselves, and some may possibly have saved themselves if the main compressed air pipe had not broken or had they been provided with self-rescuers.

This is supported by the positions and conditions of the bodies. Six of the men were burned and shocked; two were shocked; and nine unmistakably died from asphyxiation.

A study of the map showing the location of the bodies shows that six of the men were on the gangway traversed by flames at the time of the explosion. These were 1 to 5, inclusive, on the south side, and the motorman (McMurphy, No. 13) on the north side. These men had no chance and were instantly killed.

The two miners, Nos. 6 and 7, Bates and O'Leary, were working at the face of No. 2 Chute South, where they were found badly shocked and asphyxiated, but not burned.

It has been mentioned that extreme force was evident in the main rock tunnel. The positions and conditions of the four men found here, as well as all others on the North side, except McMurphy, indicate strongly that these men reached these positions after the explosion.

No. 8, P. Fleis, was employed as a loader to help McMurphy, No. 13. No. 9, Wm. Kennedy, was a miner partner of Shackley, No. 17, who worked in the face of the North Counter.

The fact that the mine car at No. 2 Chute was empty, that No. 5 Chute North contained coal, leads to the belief that Fleis, No. 8, had gone to see about loading the coal out of No. 5 Chute North, and at the time of the explosion was engaged with Kennedy, No. 9, in bucking the coal down No. 5 Chute. These two men were not burned or shocked, and showed evidence of running strenuously. If, prior to the explosion, they had been in the position where their bodies were found, they would have been in the direct path of the explosion, and their bodies would have been hurled outby, as were the timbers a short distance from where these men were found.

When the rescuers encountered Kennedy, No. 9, the first man they found, they proceeded to give him artificial respiration, but received no response. An hour had elapsed between the time he was found and when the explosion occurred.

No. 10, O'Neal, and No. 11, Flood, were working at the face of the North gangway. No violence or flame is evident at the face.

A board across the top of a car standing at the face and some lagging leaning against the car were unmolested, and indicate the men were placing lagging above a set at the face when the explosion occurred. They showed no signs of violence or burns, their bodies were in contact with each other. There can hardly be any doubt, judging from the conditions of the bodies, 13, and 1 to 5 inclusive, which were burned, the evidence of flame all around them, and the fact that they were in the direct path of the main forde; that these two men made their way from the face of the north gangway to the point where their bodies were found.

No. 12, Matson, and No. 14, Wali, were working as miners at the face of No. 3 Chute North. Their tools and conditions of the face indicates they were here at the time of the explosion. They were not burned or shocked, and judging from the conditions of No. 13, who was badly burned, these men made their way from their working place to the points where their bodies were found.

No. 13, McMurphy (motorman) was the most severely burned and broken. The top of his haulage motor was standing along side of the locomotive, and it is thought he was looking at the motor, probably oiling or greasing same. His partner, No. 8, Fleis, was certainly NOT with him when the disaster occurred. McMurphy was killed instantly.

No. 15, Barker, and No. 16, Glackin, were working at the face of No. 2 Chute North, when the explosion occurred, as evidenced by their

tools and condition of the face. They were not burned or shocked, and in all probability were making their escape when overcome.

No. 17, Shackley, was working at the face of the North counter. He was found lying face down, his face covered over with his hands, and lying with his head toward the face. He may have tried to escape and decided to return to the face and use the compressed air as the hose valve was open. He died purely from asphyxiation.

It was decidedly unfortunate that the main compressed air line was broken. If it had not been, there is hardly any doubt that some of the men could have saved themselves if they had used it.

DISCUSSION OF EXPLOSIVES USED

June 11, 1930.

Pacific Coast Coal Co.

Carbonado, Wash.

Dear Sirs:

On April 17, 1930, the bureau, through a representative, procured on its own initiative, a sample of Coalite G. L. F., manufactured by the Giant Powder Company, Giant, Calif., from a lot found in the Carbonado Mine of the Pacific Coast Coal Co., at Carbonado, Wash., in the section where the explosion occurred, in order to determine whether or not the sample met the safety requirements prescribed for permissible explosives.

The sample was denominated D-4627 by the Bureau, and it is presumed it is from the same lot as that found in the magazine, namely, No. 3 - 652.

There was repeated upon this sample a limited number of the gallery tests which this explosive passed when it was placed on the permissible list, and this sample has, within the limits of tolerance, passed all of these tests made upon it.

Yours faithfully,

cc Giant Powder Co.
Giant, Calif.

Atlas Powder Co.,
Wilmington, Del.